Continuous Clear-Sky Longwave from Surface Measurements

Contributors

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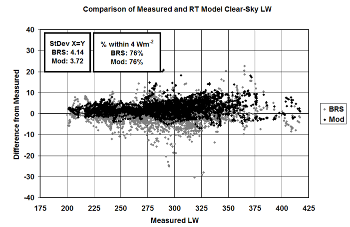
Research Highlight

An important energy driver of the Earth-atmosphere system is the radiative exchange at the surface. One of the major influences on the amount of radiative energy reaching the surface is the effect of clouds, which in general tend to decrease the downwelling shortwave (SW) irradiance and increase the downwelling longwave (LW) irradiance relative to the amounts if were clouds not present. Thus, a determination of the effect of clouds on the surface radiation is an important component to our physical understanding of the Earth-atmosphere system. To determine the radiative cloud effect, a continuous estimation of clear (i.e., cloudless) sky irradiances is needed along with the measured irradiances.

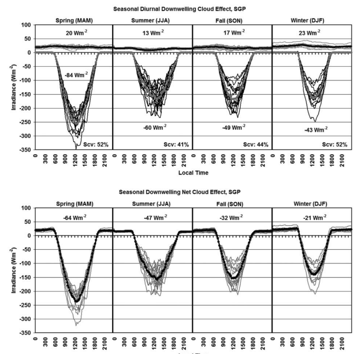
Long and Ackerman (2000) developed a methodology for detecting daylight clear-sky periods and the continuous estimation of clear-sky downwelling shortwave (SW). This methodology has been incorporated into the ARM SW Flux Analysis Value-Added Product (VAP). Similarly, we have developed the methodology described in Long and Turner (2008) for detecting "longwave effective clear-sky" periods, and calculating continuous estimations of clear-sky downwelling longwave (LW). This new methodology is a critical additional component in the full Radiative Flux Analysis (RFA) VAP that will subsume the current SW Flux Analysis VAP for ARM. The RFA VAP will then provide ARM users with all the radiative components needed to continuously compute the downwelling SW and LW cloud effects, and the full surface net radiative cloud forcing which includes the upwelling components. The RFA also provides users with estimations of sky cover (Long et al, 2006; Durr and Philipona, 2004), cloud SW transmissivity and optical depth (Barnard and Long, 2004; Barnard et al. 2008), clear-sky LW effective emissivity and all-sky brightness temperature, and an estimated cloud radiating brightness temperature.

As an example of the utility of the RFA, an analysis of data from the ACRF Southern Great Plains facility spanning the years from 1993–2007 is presented. These analyses show that the maximum downwelling LW lags the SW maximum by about a month on yearly timescales and by about three hours diurnally. The maximum all-sky and clear-sky SW and LW occurs during summer, with the greatest year-to-year clear-sky SW variability occurring in fall, but the year-to-year clear- and all-sky LW variability is about the same in all seasons. The downwelling LW cloud effect is fairly constant in the aggregate across the seasons, but the greatest SW cloud effect occurs in spring. Overall, the downwelling net cloud effect is dominated by the SW, with the greatest decrease in radiative energy reaching the surface because of clouds occurring in spring (64 W/m2) and the smallest magnitude net cloud effect occurring in winter (21 W/m2).

We have developed the ability to produce continuous estimations of clear-sky downwelling LW, without the need for inputs of continuous atmospheric



Comparison of clear-sky RT model calculations (black) and our estimates (gray) with detected LW effective clear-sky measurements from the ACRF SGP site from 1 March through 31 May 2003, showing that our LW estimates do as well as detailed model calculations in comparison with actual LW measurments.



(Top) Seasonal diurnal cycles of downwelling cloud effect for the SW (black) and LW (gray) and (bottom) net downwelling cloud effect (gray) for the years 1993–2007 for the ACRF SGP site. Aggregate averages are represented for the LW (thick black) and SW (thick gray) cloud effect (top panel) and net (black) cloud effect (bottom panel).

constituent profiles necessary for detailed radiative transfer calculations. As such, these clear-sky LW estimates serve as independent truth for testing radiative transfer calculations such as those from the ARM Broadband Heating Rate Profile VAP. This methodology also makes possible the implementation of the full RFA as an ARM VAP to be made available to all ARM users for continued research into the effect of clouds on the surface radiation budget.

Additional References: Barnard, JC, and CN Long. 2004. "A simple empirical equation to calculate cloud optical thickness using shortwave broadband measurement." Journal of Applied Meteorology 43, 1057-1066.

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Reference(s)

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Working Group(s)

Radiative Processes